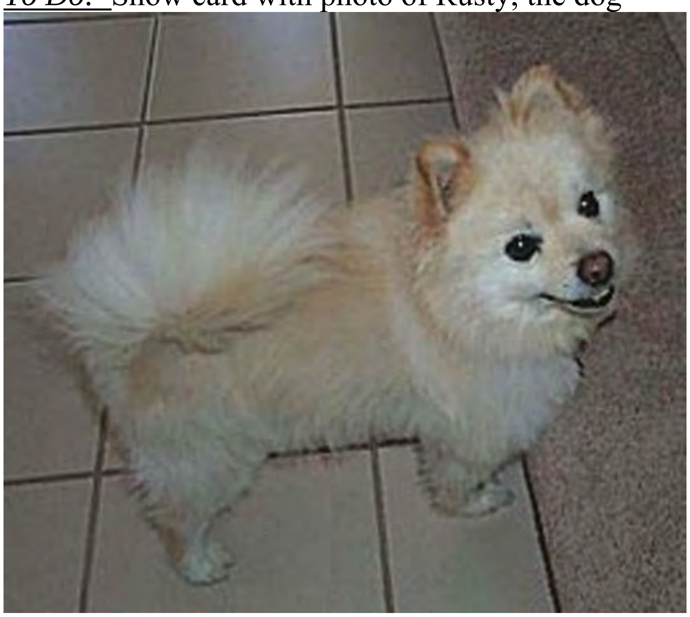
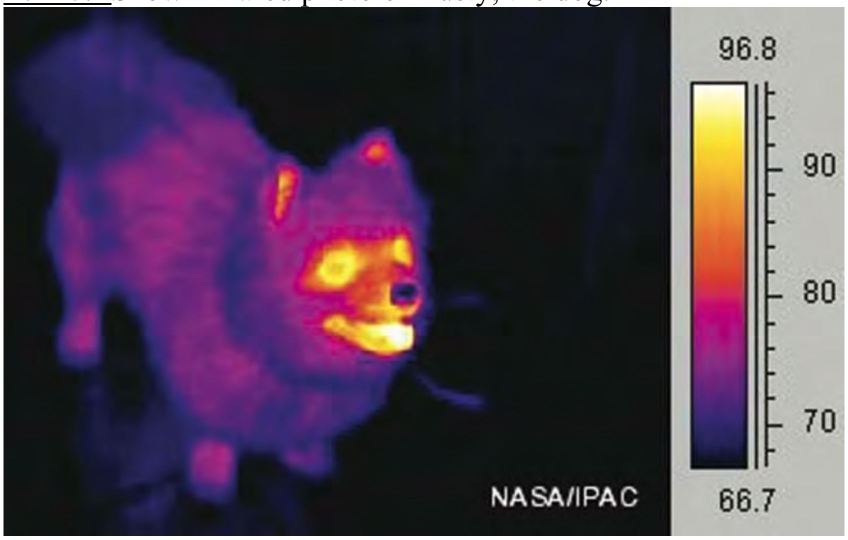
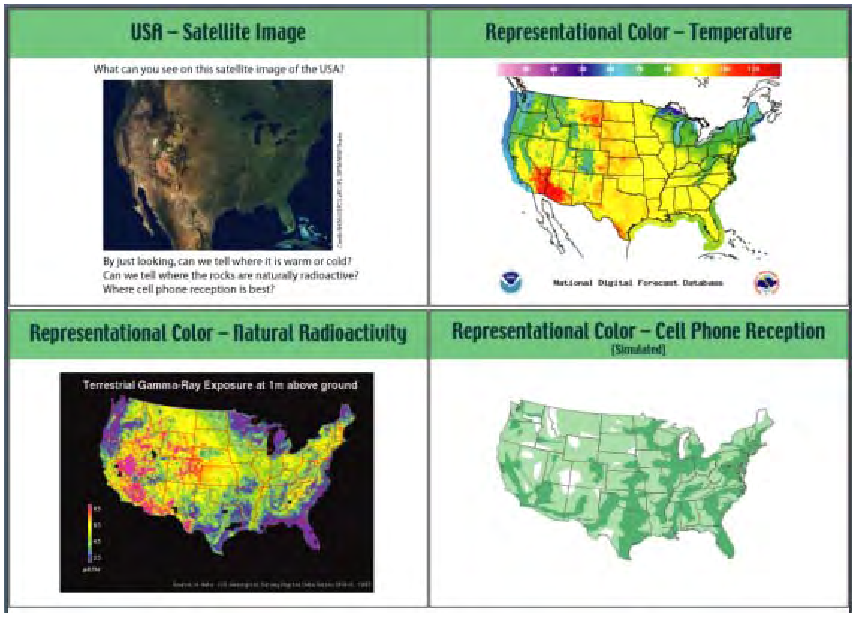
“Representational” Color: INTRODUCTION

Leader’s Role	**Participants’ Roles (Anticipated)**
Key message for your visitors to take home: There is energy/light our eyes cannot detect. There are many kinds of telescopes to detect different kinds of energy (or light).	
Materials:. Rusty card, USA images representing different information. OR PowerPoint presentation: “NotLikePhotos.ppt”, multiwavelength posters	
INTRODUCTION: *To Say:* Scientists learn a lot from the light we see coming to us from the rest of the universe. But there is more to light than just the colors of light we see in a rainbow. There is more energetic light – UV, X-Ray, Gamma-ray -- and less energetic light – infrared and radio – that our eyes are not sensitive to, that we cannot detect. We need *different* kinds of detectors. To get a complete picture and understanding of something, we need to look at it in a variety of ways. Let’s see what that means. (To continue, use either “Alternate Introduction 1” or “Alternate Introduction 2”)	
ALTERNATE INTRODUCTION 1: *To Do:* Show card with photo of Rusty, the dog  *To Say:* This is Rusty. – can you tell by looking at Rusty what parts of Rusty are warm, which cold?	No.

Leader's Role	**Participants' Roles (Anticipated)**
To Do: Show infrared photo of Rusty, the dog.  *To Say:* Does Rusty ever actually look like this? This is an infrared photo that shows us the temperature of Rusty. Which parts of Rusty are the warmest? Which coolest? What color is being used to represent the warmest parts? Could we have used other colors to represent the different temperatures? Right – any color at all! We're using representational color – We are taking energy we can't see and converting it into something our eyes CAN interpret – different colors representing different temperatures.	No! Tongue/mouth/eyes Tail/nose/feet Yellow/white Sure.

<table>
<tr><th>Leader’s Role</th><th>Participants’ Roles (Anticipated)</th></tr>
<tr><td><u>To Do:</u>
Lay out all four USA images or display them with the PowerPoint.


</td><td></td></tr>
<tr><td><u>To Say</u>:
What are these images of?</td><td>Continental United States.</td></tr>
<tr><td>If you were orbiting the Earth in a spacecraft, which of these images would be most like what you’d see from there?</td><td>Point to satellite image.</td></tr>
<tr><td>What can we tell from this? Can we see where the mountains are?</td><td>Yes.</td></tr>
<tr><td>How about the forests? Desert?</td><td>Yes.</td></tr>
<tr><td>What do these other images show us about this area of the Earth?</td><td>Temperature, radioactivity</td></tr>
<tr><td>Looking from out in space, by just using our eyes, can we tell where it is warm or cold? (point to temperature map)</td><td>No.</td></tr>
<tr><td>Can we tell where the rocks are naturally radioactive? (point to Natural Radioactivity map)</td><td>No.</td></tr>
<tr><td>Where is cell phone coverage best? (point to cell phone map)
For those we need special detectors. You can’t use just your eyes.

These other images are using representational color – taking energy we cannot detect with just our eyes and converting it into something our eyes CAN interpret – different colors representing different information about the USA.

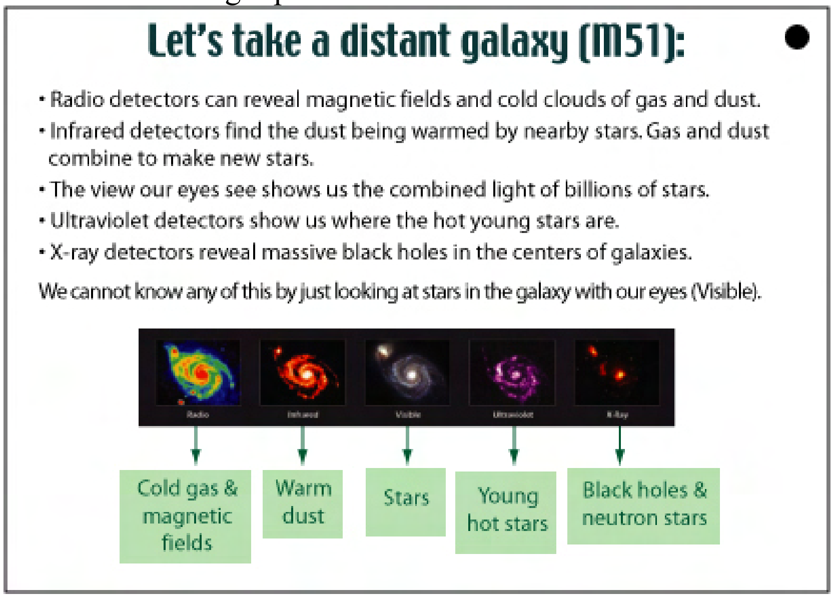
The same is true for some of the great astronomy pictures you see. (point to a multiwavelenth poster or the back of the cover card for the Universe in a Different Light postcards) The colors are beautiful, but often they are representational color, telling a much richer story to the astronomer who created it. The colors may represent composition or signal strength.</td><td>No.</td></tr>
</table>

Leader's Role	Participants' Roles (Anticipated)
<u>ALTERNATE INTRODUCTION 2:</u>	
What can someone know about me by just looking at me?	Your hair color, how tall.
If I have high blood pressure?	No.
If I haven't taken a bath for a week? What detector would tell you that?	No! My nose!
What does a doctor use to know if I have a broken bone?	X-ray
What would you use to find out if I have a fever?	Thermometer
You need different measuring/detecting devices to find out these things. You can't just use your eyes.	
(OPTIONAL CONTINUATION OF INTRODUCTION – when you want your audience to have more background or get more involved)	
<u>*To Do:*</u> Show satellite image of USA	
<u>*To Say*</u>: If you were orbiting the Earth in a spacecraft, the USA might look something like this. What can we tell from this? Can we see where the mountains are?	Yes
How about the forests? Desert?	Yes
<u>*To Do:*</u> Show temperature map of USA	
<u>*To Say:*</u> This map is used to show the temperature of the air in various part of the country. Is the air or the land that color?	No, it represents the temperature the air.
Right – it is using different colors to represent different temperatures.	
<u>*To Do:*</u> Show Natural Radioactivity map of USA	
<u>*To Say:*</u> Natural radioactivity is common in the rocks and soil that makes up our planet. There is nowhere on Earth that you cannot find natural radioactivity. Radioactive rocks naturally emit gamma-rays – in VERY low doses. If you look at a rock can you tell if it is radioactive?	No – you need a special detector
Here is a map of the natural emission of gamma-rays.	
Is the ground really these colors?	No.
Where are the gamma-rays weakest?	Examines map and answers
How do you know it is weakest there?	The key shows that purple is weakest.
Right – it is using different colors to represent different intensities of gamma-ray radiation and the key tells us what the colors mean.	

Leader's Role	**Participants' Roles (Anticipated)**
<u>To Do:</u> Show cell phone coverage map. *<u>To Say:</u>* How many of you have used a cell phone? A cell phone is a radio receiver. How do you know where the signal is strong? Can you look around you and see the radio waves coming at you?	No
What do you need to do?	Look at the bars on the phone.
What do you suppose the shading on this cell phone coverage map represents?	Dark green is strong signal. Lt green weak. White – no service.
This could once again be using different colors to represent different signal strengths.	
Would it be OK to use blue instead of green for the strong signal? Of course, as long as you have an explanation of what the colors mean.	Sure.
The same is true for some of the great astronomy pictures you see. The colors are beautiful, but often they are representational color, telling a much richer story to the astronomer who created it. The colors may represent composition or signal strength.	

Universe in a Different Light Card-Sorting Game

Leader's Role	Participants' Roles
Key message for your visitors to take home: There is energy/light our eyes cannot detect. There are many kinds of telescopes to detect different kinds of energy (or light).	
Materials: Universe in a Different Light Playing Cards and Postcards	
Presentation Tip: If you have a large group of people, you might want to give one image to each person and then let the crowd group themselves. If this is outdoors and windy and you have only a small group of people, rather than spread out the images on a table, give each person 3 or 4 images.	
SEE "INTRODUCTION" to introduce this activity.  *<u>To Say:</u>* We're standing on the surface of Earth looking out at the universe. What can we see looking through the telescopes we have outside, using our eyes as detectors? We can see the visible light with our eyes, but we need other kinds of detectors to see the other kinds of radiation or energy. NASA and others use special telescopes to detect that energy. These different kinds of energy tell us different information about objects we see in the sky. Like the maps of the USA shown in different energies, these are images of various types of objects you might see in the telescopes tonight – each in different kinds of energy (or light). Each card tells you on the back whether it is visible light energy or another kind of light energy. And what that energy is revealing about the object. The card with the "Visible" light image has the type of object printed on the back (show an example).	Stars, planets

<table>
<tr>
<td><u>To Do:</u>
Show Postcard with the five galaxy images or select something from the multiwavelength poster.


<u>To Say:</u>
For example, we have a galaxy here. This one is what we can see with our eyes (point to visible light image). This one is an infrared photo – shows where there is warm dust in the galaxy (or pick any of the images to explain).
<u>To Do:</u>
Shuffle the Universe in a Different Light Playing Cards and spread them out onto a table (or hand them out).
<u>To Say:</u>
Among the cards, there are three different images for each object. And there are [5, 6, 9] objects represented. Which ones go together? Sort them (or yourselves) into groups that represent the same object.</td>
<td>Sort cards into groups.</td>
</tr>
<tr>
<td><u>To Do:</u>
After the groups have been sorted – or they give up – bring out the “Universe in a Different Light” Postcards.
<u>To Say:</u>
Here are the answers – how well did we do? What do these images tell us about the object?
<u>To Do:</u>
Have a discussion, using information on the back of each card master, about what each image shows about the object.
(What kind of energy shows where magnetic fields are? What do the ultraviolet images show us?)
Use the Multi-wavelength poster for more examples and more information on NASA missions and telescopes making these images.</td>
<td>Examines answer cards.</td>
</tr>
<tr>
<td>Presentation Tip:
If you would like to score the group’s results:
All 9 correct: Expert observers
5 – 8 correct: Skilled observers
4 or fewer correct: Observers-in-training</td>
<td></td>
</tr>
</table>

Beginners group (5 items – 3 images of each item). These cards have a slight gray border:

- Galaxy (M51), (Visible, UV, IR)
- Open star cluster (M45), (Visible, UV, IR)
- Jupiter, (Visible, Radio, X-Ray)
- Saturn (Visible, Radio, UV)
- Sun (Visible, Radio, UV)

Advanced group (9 items – 3 images of each item):

- Galaxy (M51), (Visible, UV, IR)
- Open star cluster (M45), (Visible, UV, IR)
- Globular cluster (M13), (Visible, UV, IR)
- Planetary Nebula (M27), (Visible, IR, X-ray)
- Star-forming region (M42), (Visible, IR, UV)
- Supernova remnant (Cass-A) (Visible, IR, X-ray)
- Jupiter (Visible, Radio, X-Ray)
- Saturn (Visible, Radio, UV)
- Sun (Visible, Radio, UV)

USA – Satellite Image

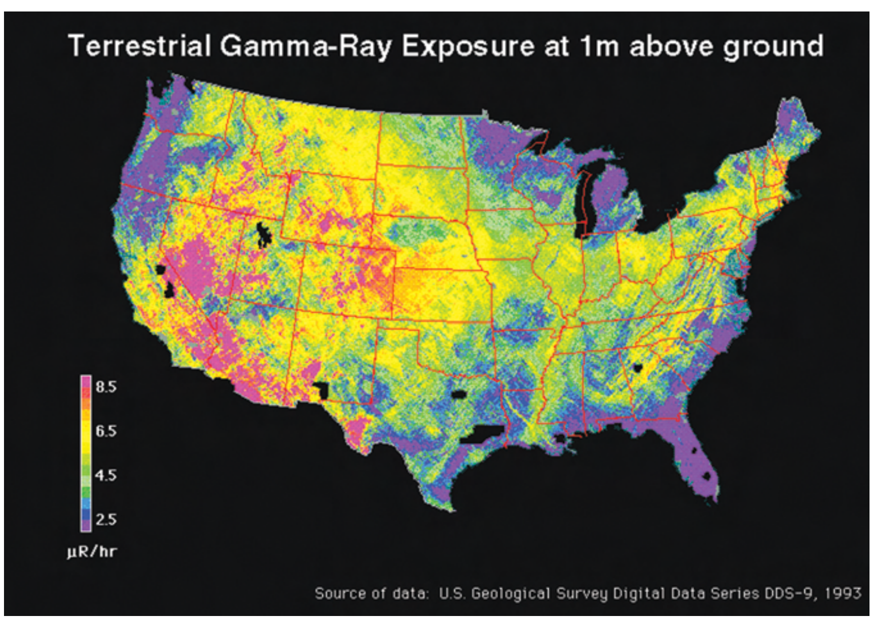
What can you see on this satellite image of the USA?

Credit: NASA/GSFC/LaRC/JPL, SRTM/MISR Teams

By just looking, can we tell where it is warm or cold?
Can we tell where the rocks are naturally radioactive?
Where cell phone reception is best?

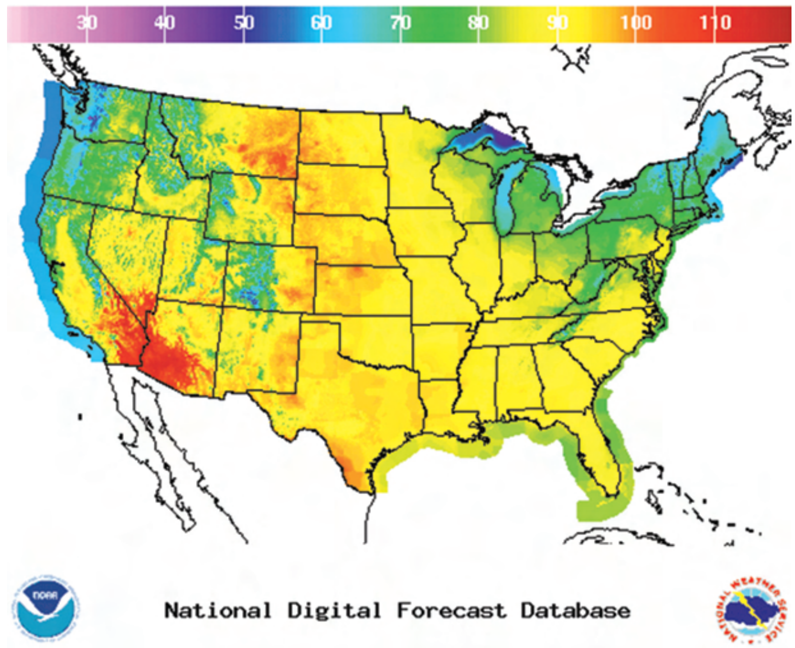
Front #1

Representational Color – Natural Radioactivity



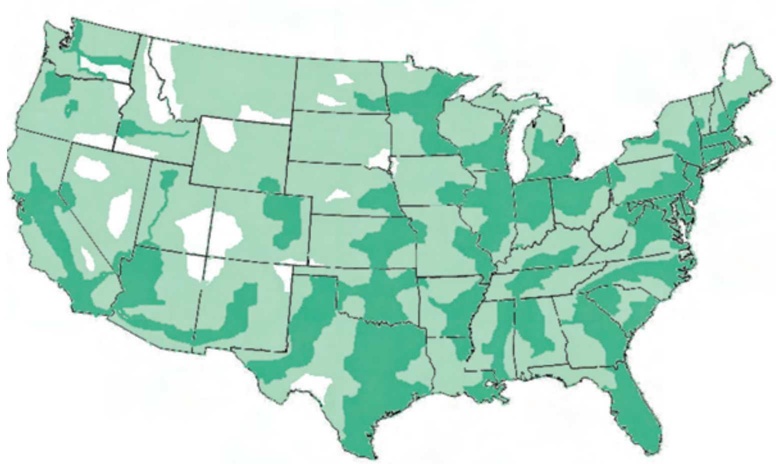
Front #2

Representational Color – Temperature

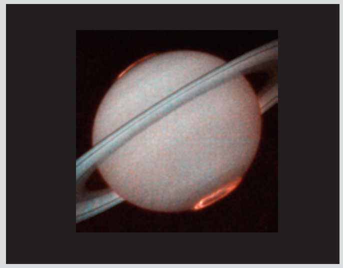
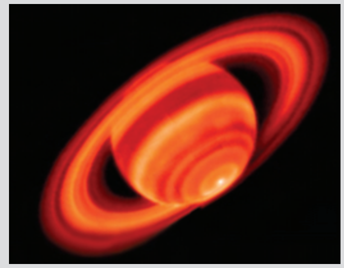


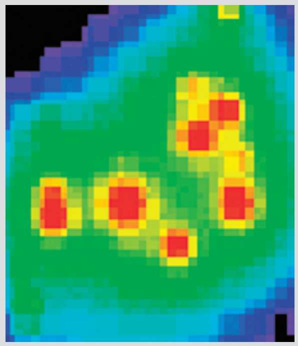
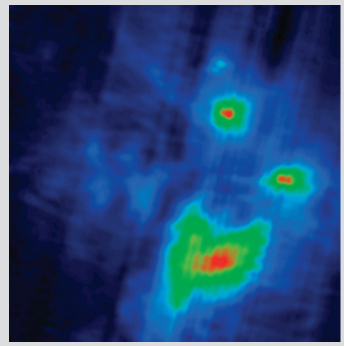
Back #1

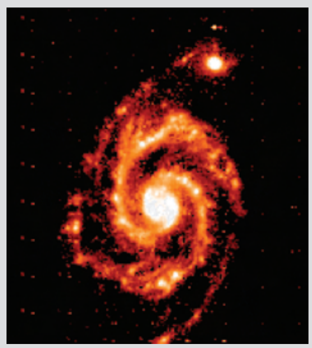
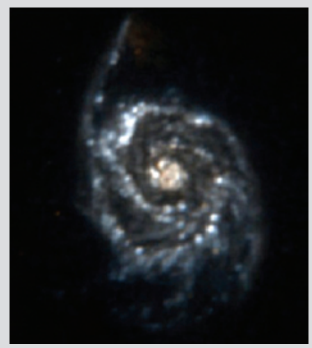
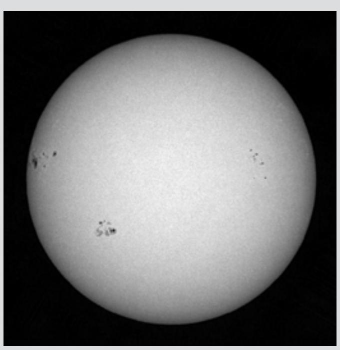
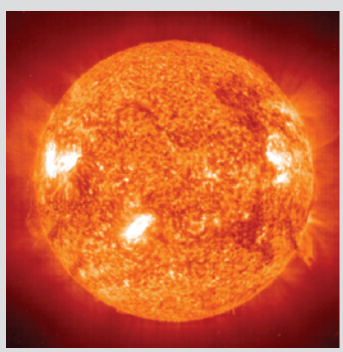
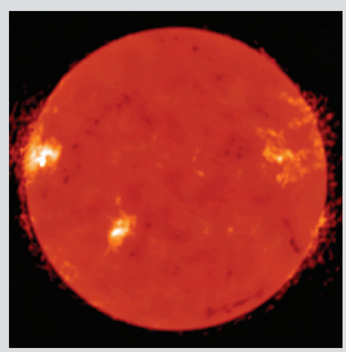
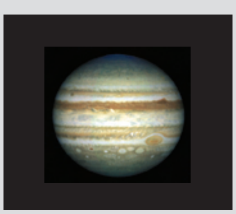
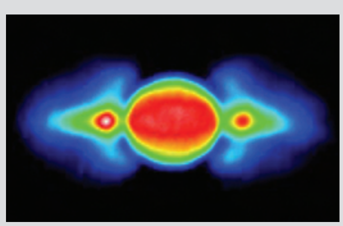
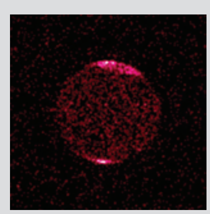
Representational Color – Cell Phone Reception
(Simulated)



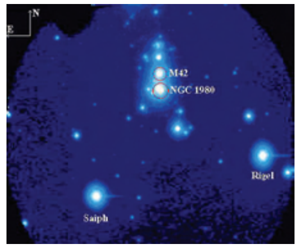
Back #2

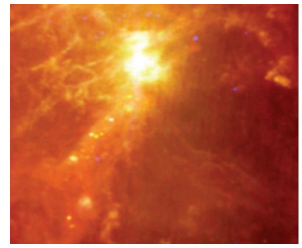




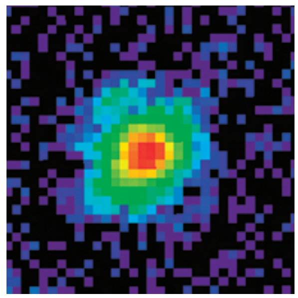



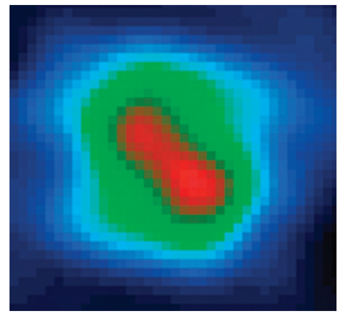









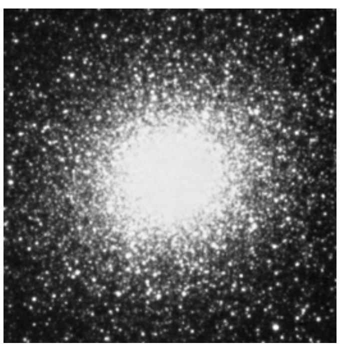
		Saturn
Infrared	**Ultraviolet**	**Visible**
Warmer & Cooler Areas	*Aurora*	
Credit: W.M. Keck Observatory/NASA/JPL-G. Orton	Credit: J. Trauger JPL/NASA	Credit: NASA/JPL/Voyager
		Open Star Cluster
Infrared	**Ultraviolet**	**Visible**
Warm Dust	*Hot Young Stars*	
Credit: IRAS	Credit: Midcourse Space Experiment	Credit: Alexander Jäger Interessengemeinschaft Astronomie
		Galaxy
Ultraviolet	**Infrared**	**Visible**
Hot Young Stars	*Warm Dust*	
Credit: GALEX, NASA	Credit: ESA Infrared Space Observatory	Credit: Digitized Sky Survey
		Sun
Radio	**Ultraviolet**	**Visible**
Magnetic Fields	*Hot Gases*	
Credit: Nobeyama Radio Observatory	Credit: NASA/ESA SOHO	Credit: Big Bear Solar Observatory
		Jupiter
X-ray	**Radio**	**Visible**
Aurora	*Magnetic Fields*	
Credit: NASA/CXC/SWRI/G.R. Gladstone et al.	© Australia Telescope National Facility	Credit: NASA

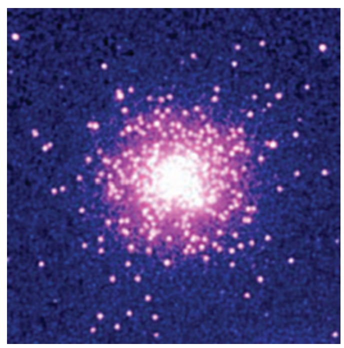

N
E
M42
NGC 1980
Rigel
Saiph

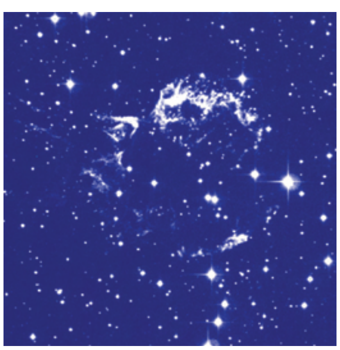


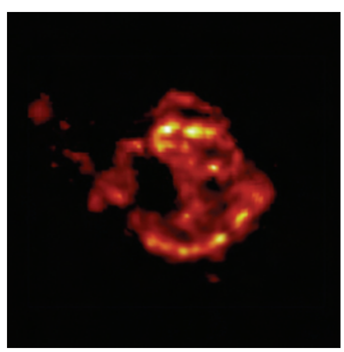


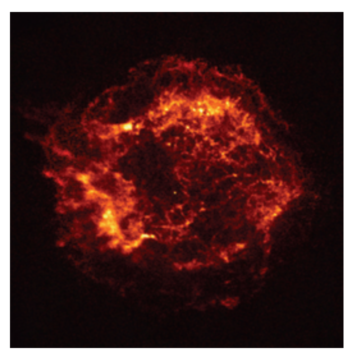












Nebula of Gas & Dust (Star-Forming Region)

Infrared

Warm Dust

Credit: IRAS

Ultraviolet

Hot Young Stars

Credit: Midcourse Space Experiment

Visible

Credit: Bill Drelling

Planetary Nebula (Dying Star)

Infrared

Dust

Credit: IRAS

X-ray

Hot Star Core

Credit: ROSAT

Visible

Credit: 2MASS

Globular Star Cluster

Infrared

Dust

Credit: IRAS

Ultraviolet

Hot Star Cores

Credit: FOCA

Visible

Credit: Digitized Sky Survey

Supernova Remnant

X-ray

Hot Gases

Credit: NASA/CXC/SAO/Rutgers/J. Hughes

Infrared

Warm Dust

Credit: Infrared Space Observatory

Visible

Credit: Digitized Sky Survey

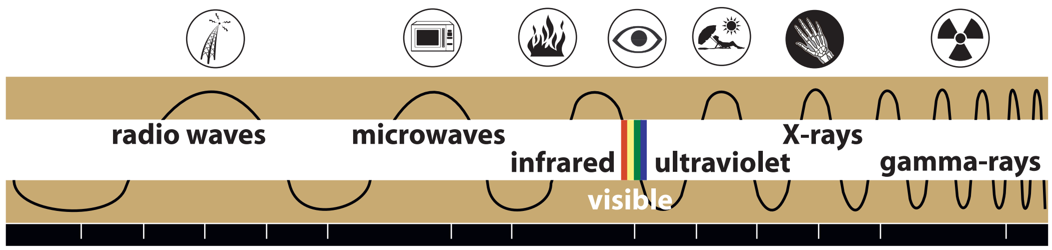
The Universe in a Different Light

There is more to the Universe than meets the eye. By looking in space using detectors for energy invisible to our eyes, we get a more complete story.

Different energies of light reveal many secrets about the lives of stars and galaxies that are otherwise hidden from us.

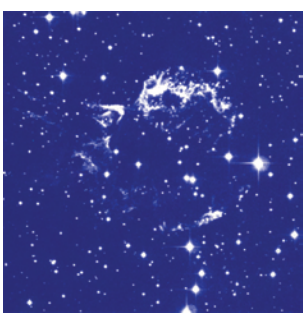
The attached cards contain examples of objects commonly observed with backyard telescopes. The cards contain a typical visible light image and a few images in different energies (or wavelengths) of light.

The explanations on the back of the cards tell what astronomers are discovering by studying objects in energies of light invisible to the eye.



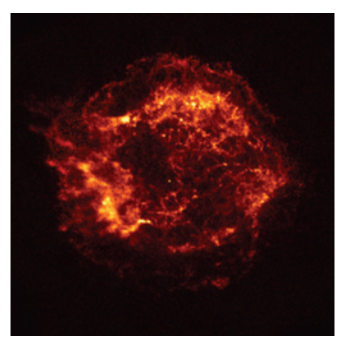
Front #1

Supernova Remnant
(Cassiopeia-A)



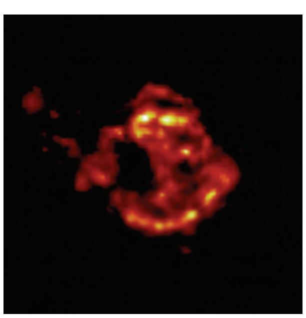
Credit: Digitized Sky Survey

Visible



Credit: NASA/CXC/SAO/Rutgers/J. Hughes

X-ray



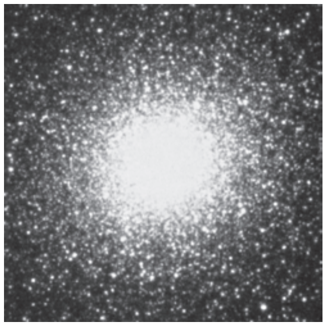
Credit: Infrared Space Observatory

Infrared

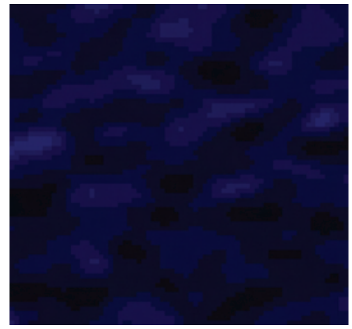
Front #2

Globular Cluster
(M13 – Hercules Cluster)

Credit: Digitized Sky Survey



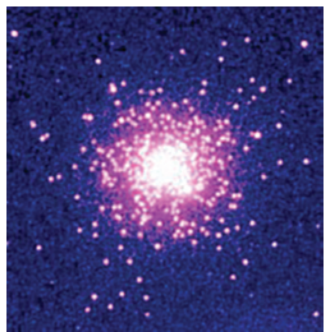
Visible



Credit: IRAS

Infrared

Ultraviolet

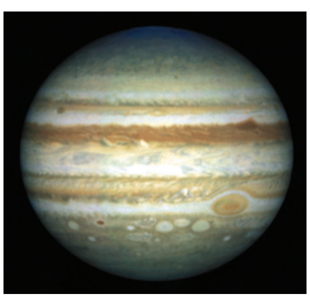


Credit: FOCA

Front #3

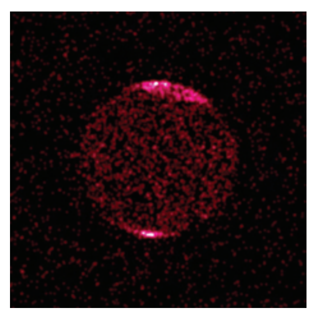
Jupiter

Credit: NASA



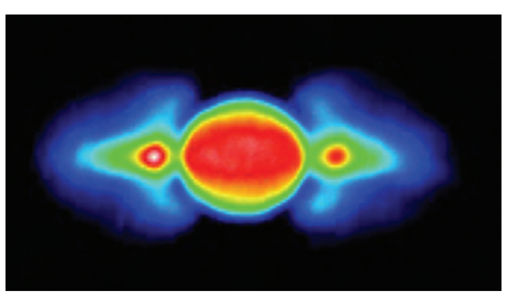
Visible

Radio



Credit: NASA/CXC/SWRI/G.R. Gladstone et al.

X-ray



© Australia Telescope National Facility

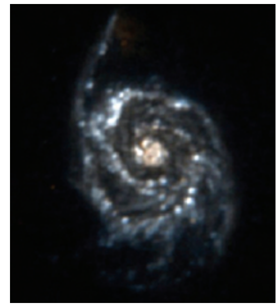
Front #4

Galaxy
(M51)

Visible

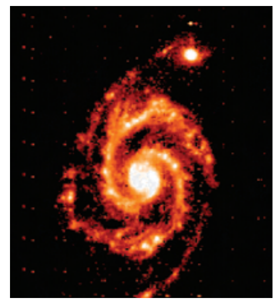
Credit: Digitized Sky Survey

Ultraviolet



Credit: GALEX, NASA

Infrared



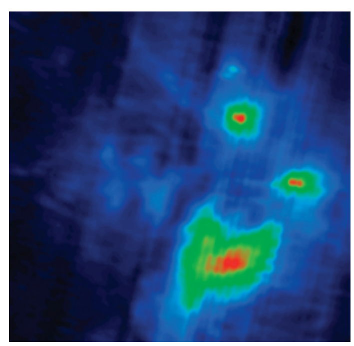
Credit: ESA Infrared Space Observatory

Front #5

Open Star Cluster
(M45 – Pleiades Cluster)

Credit: Alexander Jäger
Interessengemeinschaft Astronomie

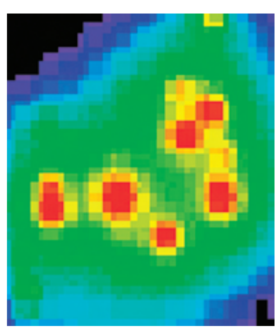
Visible



Credit: IRAS

Infrared

Ultraviolet

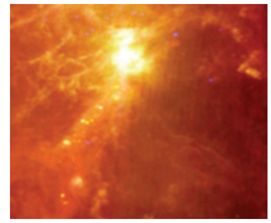


Credit: Midcourse Space Experiment

Front #6

Star-Forming Region – Nebula of Dust and Gas
(Constellation of Orion & M42)

Credit: Bill Drelling

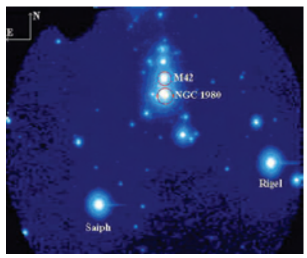


Credit: IRAS

Ultraviolet

Visible

Infrared



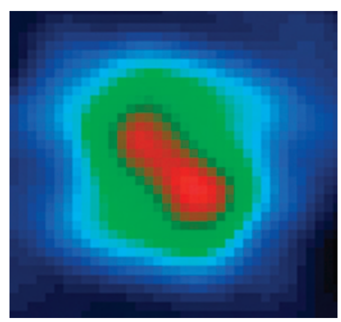
Credit: Midcourse Space Experiment

Front #7

Planetary Nebula – A Dying Star
(M27 – Dumbbell Nebula)

Credit: 2MASS

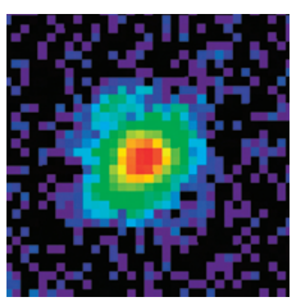
Visible



Credit: IRAS

Infrared

X-ray

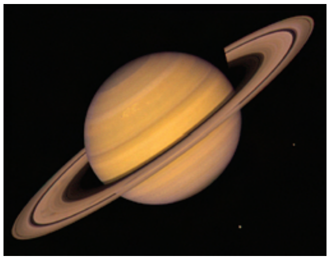


Credit: ROSAT

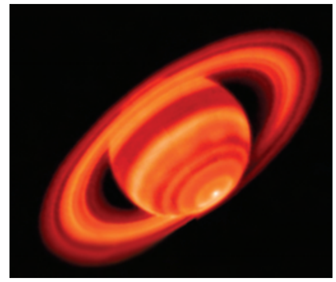
Front #8

Saturn

Credit: NASA/JPL/Voyager



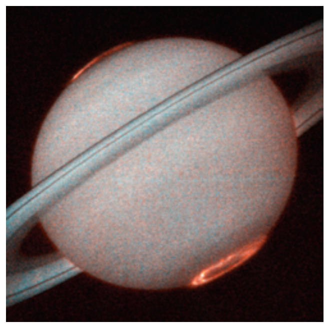
Visible



Credit: W.M. Keck Observatory/NASA/JPL-G. Orton

Infrared

Ultraviolet

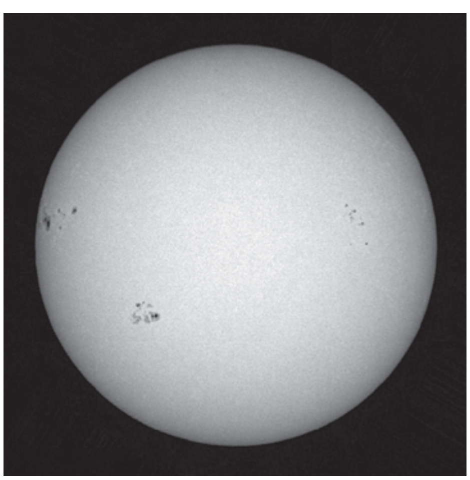


Credit: J. Trauger JPL/NASA

Front #9

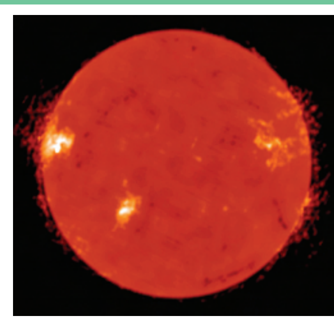
The Sun

Visible



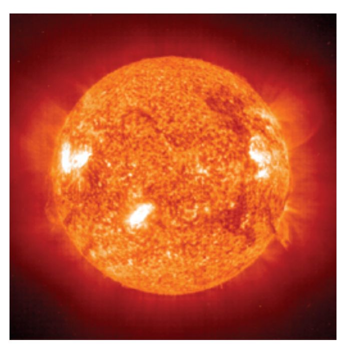
Credits: Big Bear Solar Observatory

Radio



Credits: Nobeyama Radio Observatory

Ultraviolet



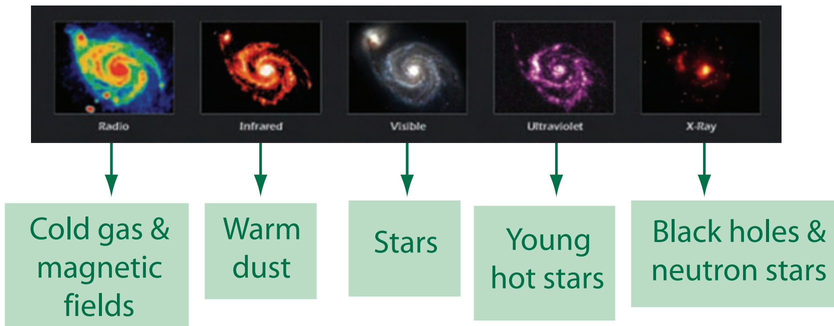
Credits: NASA/ESA SOHO

Front #10

Let's take a distant galaxy (M51):

- Radio detectors can reveal magnetic fields and cold clouds of gas and dust.
- Infrared detectors find the dust being warmed by nearby stars. Gas and dust combine to make new stars.
- The view our eyes see shows us the combined light of billions of stars.
- Ultraviolet detectors show us where the hot young stars are.
- X-ray detectors reveal massive black holes in the centers of galaxies.

We cannot know any of this by just looking at stars in the galaxy with our eyes (Visible).



Back #1

Supernova Remnant
(Cassiopeia-A)

This is what remains of the material expelled from a huge star when it died in a supernova explosion.

Visible light: Supernova remnants are often unimpressive in visible light. They barely reveal the expanding shell of gas from the powerful supernova explosion. What can you see in the telescope?

Infrared: Shows the warm dust left over from the explosion. Supernova explosions create the dust of heavy elements, like iron and gold, and spread them out into space. It is this dust that mixes with other dust and gas between the stars and eventually contributes to building new stars and planets, maybe a planet like Earth.

X-ray: The bright regions show where material from the explosion is crashing into the gas and dust of interstellar space, heating it to millions of degrees. These collisions contribute to compressing the gas and dust and after millions of years, forming new stars from the wreckage of these dead stars.

Back #2

Globular Cluster
(M13 – Hercules Cluster)

Visible light: When you look through a telescope you see a spherical cluster of thousands of stars tightly bound together by gravity. Do you suppose these stars are young or old?

Infrared: What happened to the cluster of stars? Infrared light Is supposed to reveal dust. The view in infrared of this cluster shows us that there is no dust - nothing from which new stars can form. These stars are very old - any dust that was leftover from their formation billions of years ago is long gone. No young stars are in this cluster.

Ultraviolet: If there are no young stars in this cluster, why is the ultraviolet image so bright? These stars are hot, but they are not young. This image shows us which ones are very compact stars nearing the end of their lives: white dwarfs. These stars have lost their outer atmospheres and have used up most or all of their nuclear fuel. All that is left of these is an exposed hot collapsed core.

This is a quiet, serene cluster of old stars all living together for billions of years.

Source: http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m13.html

Back #3

Jupiter

Visible light: As you look at Jupiter through the telescope, note the bands of clouds and its slightly flattened appearance. Watching the features on Jupiter rotate across its face, we can tell this huge planet rotates about once every 10 hours. This fast rotation causes Jupiter to be slightly flattened at the poles.

Radio: Is this Jupiter? Radio energy reveals magnetic fields. In this image, you are able to see that Jupiter has strong magnetic fields - similar to, but much stronger than, the magnetic fields on Earth. Can you see magnetic fields with your eyes? A compass will show you the direction of the magnetic fields on Earth, but we need radio telescopes to reveal the magnetic fields on Jupiter.

X-ray: This image shows us that high-energy particles trapped in Jupiter's magnetic field are accelerated along the lines of force and slam into Jupiter's poles, releasing a lot of energy. Jupiter's strong magnetic fields generate a more energetic aurora (northern and southern lights) than Earth's fields do – so energetic that it is invisible to our eyes.

Back #4

Galaxy
(M51)

Visible light: When you look through the telescope at a galaxy, you'll see a fuzzy patch of light. Long exposures using cameras or CCDs will show much more detail, like this image. You are seeing the glow from billions of stars, but what kind of stars are they?

Infrared: In addition to showing stars, infrared reveals dust warmed by stars within the spiral arms. These dusty regions are cool, not nearly as hot as stars, but much warmer than the background of space. Dust and gas are what new stars are made from.

Ultraviolet: Shows star formation concentrated in the spiral arms, since ultraviolet reveals where the massive hot young stars are. What happened to the companion galaxy at the top? Notice that it is not visible in the ultraviolet image, telling us that this region has little or no new star formation taking place.

Back #5

Open Star Cluster
(M45 – Pleiades Cluster)

Visible light: You might see a hazy patch in the sky, but the view through a telescope or binoculars reveals many bright stars in a loose group. Do you think these stars are old or young?

Infrared: The view in infrared shows us the warm dust leftover from the recent formation of these stars just a few million years ago. These are *new* stars!

Ultraviolet: The hottest stars can be seen in the ultraviolet image. Can you see how the red spots (which show the highest emissions of ultraviolet light) match the locations of the brightest stars in the visible image?

This is a loose association of new stars, just breaking out of the cocoon of gas and dust where they formed–ready to go out and have lives of their own. These stars will eventually separate from each other–some perhaps with families of planets around them.

Source: http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m45.html

Back #6

Star-Forming Region – Nebula of Dust and Gas

(Constellation of Orion & M42)

Visible light: This image of the constellation shows stars of all ages and temperatures as we would see with our eyes. Can you see a faint, hazy patch? What can we find out about what this is?

Infrared: The brightest regions in infrared show where the highest concentrations of dust are. The entire region seems to glow with warm dust clouds. Is the fuzzy patch one of the brightest regions? New stars are probably forming from all this dust. Notice how some of the stars are almost invisible. Very hot stars emit most of their light in ultraviolet and visible light energies. They generate only a little energy at the cooler infrared levels. What kind of stars do you suppose are forming in the fuzzy patch?

Ultraviolet: This view of the area around the fuzzy patch shows the nebula hot with the ultraviolet light of massive young stars. Notice how brightly some of the stars shine in ultraviolet – these are the really hot stars!

Back #7

Planetary Nebula – A Dying Star

(M27 – Dumbbell Nebula)

Visible light: A shell of gas and dust is being expelled from an average star (like the Sun) nearing the end of its life. Our star might have a shell around it like this in a few billion years.

Infrared: Infrared light from cool dust traces the outline of the dusty cloud around the dying star. This dust is enriching space with elements like oxygen and calcium to make new stars and their planets - and maybe beings like you!

X-ray: The hot X-rays coming from the center of the planetary nebula (red in the center indicates the most intense X-rays) reveal the exposed hot core - the remains of the dying star - a white dwarf.

Source: http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m27.html

Back #8

Saturn

Visible light: In visible light we begin to see features in Saturn's atmosphere as well as in its vast ring system.

Infrared: The image shows both the planet and the rings radiating heat absorbed from the Sun. The lighter the color, the warmer the area. We can see that Saturn's south pole is warmer than its equator. The equator is about -300° F, so at -188° F, the south pole is comparatively pleasant!

Ultraviolet: Ultraviolet reveals Saturn's auroras which are over 1,000 miles above the clouds. These auroras are caused by solar wind particles guided to Saturn's polar regions by the planet's magnetic field where they collide with gases in Saturn's atmosphere–Saturn's equivalent of the Northern Lights.

Source: http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m13.html

Back #9

The Sun
A close-up view of a star!

Visible light: This is the view through a telescope with a solar filter on it. What do you see? Some dark spots? Do you suppose all stars have dark spots like this? What are they? They appear dark because the are cooler than the surrounding gas which is glowing at about 6000° C. Let's look at other energies of light to find out more.

Radio: Do you notice the regions of strongest radio energy seem to correspond with the placement of the sunspots? Radio can reveal magnetic fields. Does it look like there are strong magnetic fields near sunspots?

Ultraviolet: Magnetic fields trap hot gases. The ultraviolet allows us to see hot flares and material looping out of the Sun at temperatures of up to a million degrees. Solar storms and flares, which can disrupt communications on Earth, result from changes in the magnetic fields of the Sun.

Back #10

Optical Rusty

This is Rusty.
Can you tell by just looking what parts of him are warm and which are cooler?

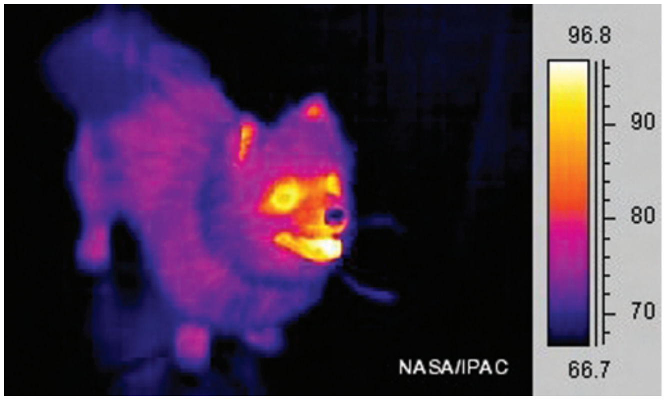
Front #1

Optical Rusty

This is Rusty.
Can you tell by just looking what parts of him are warm and which are cooler?

Front #1

Infrared Rusty

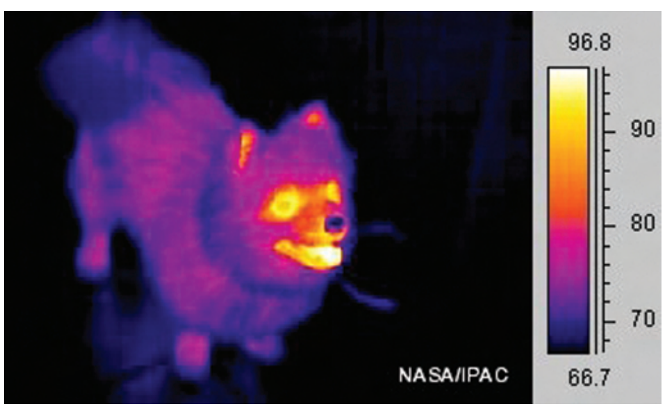


REPRESENTATIONAL COLOR

This is an infrared photo that shows us where Rusty is warm and cool.
Which parts of Rusty are the warmest?
What color is being used to represent the warmest parts?
We are taking energy we can't see and converting it into something our eyes can interpret: different colors representing different temperatures.

Back #1

Infrared Rusty



REPRESENTATIONAL COLOR

This is an infrared photo that shows us where Rusty is warm and cool.
Which parts of Rusty are the warmest?
What color is being used to represent the warmest parts?
We are taking energy we can't see and converting it into something our eyes can interpret: different colors representing different temperatures.

Back #1

